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server; the same assistant should also mark, on each occasion, the time on shore. In short, every care should be taken to have all the circumstances of the observations the same, and, hence, the fixed errors in the same direction; they are thus eliminated from the result, which depends in meridian distances not on the actual values obtained, but on their difference.

12. When the time is limited, or it is desired to complete the observations for position by one trip to the station, circum-meridian observations of stars in pairs may be used, as usual, for latitude, and east and west prime vertical stars for longitude, selecting harmonious pairs and accepting the mean result.

13. As an alternative, a combination of NE., SE., SW., and NW. stars may be used for Sumner lines, and, if symmetrically selected, will give a very accurate result, as heretofore explained. The intersection may be profitably worked out, instead of being found by plotting.

14. It is sometimes forgotten that, in establishing meridian distances, the first and last observations for chronometer error may be at the place to be located, and the intermediate observations at the known place.

POLAR CLIMATE IN TIME THE MAJOR FACTOR IN THE EVOLUTION OF PLANTS AND ANIMALS.

ABSTRACT OF A PAPER

BY

G. R. WIELAND.*

Under this title the author enters into a field of discussion which has attracted the masters of thought in several branches of science. Astronomy, physics, geology, and biology in its wide sense concern themselves with this problem. Dr. Wieland, as a student of biological science, takes as a fundamental proposition:

> Life, then, as far as we have succeeded in scrutinizing it, is a function of variable mechanical factors combined with chemism, which is fixed, and of climate as dependent mainly on the manner of terrestrial reception of the solar radiant energy. Climate, although following a fairly fixed trend, in itself subject in so far as the globe is concerned to an evolutionary course, is at all times in given localities subject to the accidence of countless movable conditions.

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* Amer. Jour. Sci. XVI, 401–430. Dec., 1903.

Furthermore, his main theorem is,

> That the great evolutionary *Schauplatz* was boreal is possible from the astronomical relations, probable from the physical facts, and rendered an established certainty by the unheralded synchronous appearance of the main groups of animals and plants on both sides of the great oceans throughout post-Palæozoic time. Moreover, the efficient cause of this origin in high latitudes of hardy and effective colonizers is to be sought for in the vicissitudes of polar climate as compared with the more equable and static conditions of the tropics.

The author concludes that during geological time the earth's axis has remained so nearly fixed that no changes of climate can be assigned to its variation. The changes in orbital eccentricity have produced the greatest changes in climate, and the changes must have been at a maximum at the poles and at a minimum at the equator. The fossils show that there can have been no glacial periods in the north polar area prior to Miocene time; there must have been instead "prolonged hot, or frosty, or cool, or rainy, or dry seasons." The polar areas, however, have been the scene of steadily increasing climatic change. Adhering to the nebular hypothesis of Kant and Laplace, Dr. Wieland believes that crustal stability must have obtained at the poles long before it did at the equator, and that it is reasonable to conclude that life in its lower forms appeared first at the poles. It is, however, impossible to trace the march of events among the ubiquitous aquatic animals and spore-bearing plants of Palæozoic time, forms which were easy and rapid of distribution.

Mesozoic strata present several fresh-water beds on the continental mainlands, and have preserved the remains of early representatives of the more highly-organized vertebrates and plants. These are delicate horizon-markers, and give clues to the directions of migrations. The earlier expression of the north to south movements of types originating at the far north consists of the fact that the small and delicate so-called mammals of the Jurassic are much alike in beds on both sides of the Atlantic, which are supposed to be of the same age. In the Cretaceous this general fact of migration from north to south is accentuated. Throughout the Tertiary the more nearly complete the record, the greater the parallelism and synchronism in the succession of similar vertebrate faunæ in Europe and America. Wortman was the first to emphasize the great extent of this synchronous succession and its bearing on the question of the polar origin of the main ancestral mammalian stocks.

The facts of the life of oceanic islands show that the dispersion of land vertebrates across ocean barriers is nearly impossible. It is, however, no more conceivable that there was a *constant* interchange of vertebrates between America and Europe by way of arctic land masses existing in the Tertiary, because at all times since the earliest Mesozoic the climate prevailing in the Arctic regions would have entailed too many and too great changes in mode of life. The evidence of the fossils themselves is against the theory of austral origin. The only satisfactory hypothesis is that of a common north polar origin of the principal ancestral vertebrate stocks, which dispersed secondarily outwards in waves or impulses from the polar seas and spread over America and Eurasia, and this is sustained through the following reasons:

(a) The parallelism between the life of America and Eurasia is apparently greater than that of the more isolated continental areas of the far south—South Africa, Notogæa, and Neogæa.

(b) The great land masses lie about and project well within the Arctic area, and have therefore afforded the presumably wider geographic range.

(c) There is much reason to believe that the lands near the north pole were always much divided into islands and peninsulas, and were thus, as elsewhere explained, a more active scene of plant and animal change than even a much larger and more isolated body of land such as Antarctica may have been.

(d) It is reasonably certain that over a large portion of the Antarctic area the continuity of life was interrupted by glacial conditions in the Permian.

Turning to the botanical record, Dr. Wieland follows Saporta, and particularly Asa Gray, in holding that the fossils show that there was a universal southward dispersion of plants from the northern polar area during Tertiary time. Dr. Wieland holds, furthermore, that the generalized tropical conditions of early Palæozoic time prevailed in the north even into the early Jurassic. By the mid-Cretaceous the plants give striking evidence of climatic change. The conditions under which the life of a given locality thrives are always, in the long run, retreating southward, and other and hardier forms are always to be found to the northward. Experience has taught the agriculturist that northern varieties of plants are the hardier and that the southern stocks are weaker and even impossible of successful introduction. The same thing applies to animals. Since secular cooling is always going on, and since the general nature of growth is constant, a condition of high northern organic potential must always exist, which results in a southward stress and movement. Life utterly fails to make its way northward again.

Light has had as much effect as heat and moisture in determining the life of plants. All three factors have been variable to the utmost degree in the polar areas, and in the periods of high eccentricity there must have been the most extreme changes and diversities in cloudiness, rainfall, dryness, heat, and frostiness in those regions. The possible difference of thirty-six solar days in the length of the seasons would in many cases produce totally different weather conditions during the periods of reproduction, sometimes favourable, sometimes adverse. Sudden changes of climate or the transportation from warm to much colder localities and *vice versa* result in very obvious changes in animals and plants, but they do not usually leave the stock a vigorous one. As polar changes were mainly governed by the precession of the equinoxes, the time scale was one of 12,934 years for the passing from rigorous to *melior* conditions or the reverse throughout the successive periods of high eccentricity.

Without attempting to follow out further the several lines of evidence of northern origin and of southern migration and displacement, the author considers it fully established that all the factors of climate and, therefore, the main alternative potentialities producing organic evolution have been in the highest degree variant in the polar areas. This being true, the grouping of the continents about the north pole so that they have come to cover fully 300° of the Arctic circle would make it reasonable to suppose that the northern circumpolar area probably has been, ever since the older Palæozoic at least, the main evolutionary centre from which life has radiated. This theoretical view is supported by overwhelming proof that such has been the fact, and that it is from the Arctic area that the greatest waves of change have swept out to lessen and disintegrate, though not necessarily to cease, in the more static conditions of the tropics.

E. O. H.

A CASE OF GEOGRAPHIC INFLUENCE UPON HUMAN AFFAIRS.

BY

GEO. D. HUBBARD.

INTRODUCTION.—Among the geologic questions presented within the bounds of Illinois perhaps none has a greater economic bearing than the glacial problem. It is the purpose of this paper to look at glaciation and its results in a limited portion of Illinois, from the point of view of geographic influence upon plants, crops, and animals, and upon man's distribution, occupations, successes, and failures.